DATA ANALYSIS TOOLS USING JAVA/INTERNET TECHNOLOGY AT ARNOLD ENGINEERING DEVELOPMENT CENTER*

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ABSTRACT

AEDC is in the process of bringing Virtual Presence capabilities to its customers through Data Analysis Tools using the Java Programming Language and Internet Technologies. These technology tools are maturing at a time when U.S. dominance and market share are eroding. Thus, these tools provide an important contribution for the U.S. to strengthen its share of the world aircraft market. AEDC's AeroGraph is a powerful tool for remotely accessing and reviewing wind tunnel test data by the aerospace industry and is the main topic of this paper. AeroGraph is only one of many components currently being developed at AEDC during this virtual presence era.

FACILITY OVERVIEW

The Arnold Engineering Development Center (AEDC) is the most advanced and largest complex of flight simulation test facilities in the world with 53 aerodynamic and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, arc heaters, hyperballistic ranges, and other test units. Twenty-seven of the center's test units have capabilities unmatched elsewhere. Facilities can simulate flight conditions from sea level to altitudes more than 100,000 ft, and from subsonic velocities to those well over Mach 20.

Test units are employed in proof of theory (concept, material, design, and performance evaluation) throughout the environmental conditions that systems are expected to encounter in performance of their missions. Environmental testing continues to play a vital role in obtaining a maximum return from Research and Development, Test and Evaluation by ensuring a high degree of quality assurance prior to

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a system becoming operational. This testing complements the more expensive and often hazardous flight test phase of systems acquisition, and can save time and resources in the overall development, acquisition, deployment, and sustainment process.[1]

PRODUCTS/CUSTOMERS

AEDC has contributed to the development of practically every one of the nation's top priority aerospace programs, including the Atlas, Titan, Minuteman and Peacekeeper ICBMs, Projects Mercury, Gemini and Apollo, the space shuttle, F-15, F-16, F/A-18, F-22, F-111, F-117, C-5, C-141, X-29, B-1, and B-2 aircraft, Navstar Global Positioning System satellites, the Inertial Upper Stage, the anti-satellite program, Trident submarine-launched ballistic missile, Tomahawk, Air-Launched Cruise Missile, Advanced Medium-Range Air-to-Air Missile, JDAM, JSF, and JASSM.[2]

Customers include the Department of Defense (Army, Navy, and Air Force), the National Aeronautics and Space Administration, domestic and foreign private industry, allied foreign governments, and educational institutions.

INTRODUCTION

Traditionally at AEDC, wind tunnel testing requires the customers to bring a group of engineers and scientists to the site. These engineers are needed for their expertise in gathering and reviewing the test data. Depending on AEDC's test schedule and the test's duration, these engineers, along with AEDC's engineers, may not have enough time to perform an in-depth analysis of the data. Also, the rapid acceleration of the technological revolution since the early 1980's has created an information overload. The quantity of data that researchers can assemble, acquire, and reduce for analysis has jumped from a few megabytes to gigabytes. Therefore, the aerospace customers often receive the data several months after the test, depending on the level of analysis done at AEDC. By this time, the results often indicate valuable insights and areas that could have been explored during the test, if the data had been conveniently available. Researchers no longer analyze the data on mainframe computers, preferring instead to use a variety of computers (PCs, Suns, Dec, Alphas, Macintoshes, Silicon Graphic's, etc.). AEDC is faced with a massive overload of data needing to be managed with customers wanting to plot and analyze their data on-line during a test. AeroGraph is to expedite the transfer of reduced data to the customers, reduce the number of customer engineers required on site, and provide faster analysis capabilities. It is the first attempt to bring virtual presence to our wind tunnel control rooms.

REQUIREMENTS

AeroGraph is the product of a project called Test Support Software Modernization . The original intent of this project was to combine two existing complex graphics systems; the Analysis and Display System (ADS) used by the Propulsion Wind Tunnel (PWT) and Von Karman (VKF) facilities, and the Test Interface Graphical Evaluation Resource (TIGER) system used by Engine Test Facility (ETF). Both of these systems highly satisfy their current analysis requirements. After several meetings and discussions, it was obvious that for future growth and commonality, a product was needed that would take advantage of the Internet, web tools, Java, and graphical browsers such as Netscape Navigator and Microsoft

Internet Explorer. The spiral design approach and rapid prototyping would be used as the software development methods. This product, AeroGraph, would consist of basic graphical tools usable on the Internet with the potential to grow into the multi-functional graphic systems mentioned above with the added capability of virtual presence.

The features required of AeroGraph are as follows:

- Platform Independent
- Run on Internet/Intranet
- Access current ADS database file / Easily adaptable to other databases
- User-friendly point-and-click environment
- Multiple XY plots
- Manual/Automatic Scales
- Mouse Drag/Drop Scales
- Store setup files
- Sorting capability
- Tabular displays

Due to these requirements, Java became the language of choice. One obvious advantage of Java is a run time library that produces platform independent code. The same code can be used in Windows 95, Solaris, Unix, Mac OS, etc., This is certainly necessary for Internet programming. Users will download Java applets (bytecode) from the Internet and execute them on their own machines with their Java enabled browsers. The authors of Java describe it with the following phrase of buzzwords.

"Java: A simple, object-oriented, network-savvy, interpreted, robust, secure, architecture neutral, portable, high-performance, multithreaded, dynamic language."[3,4]

OVERVIEW

The AeroGraph framework (Fig. 1) includes a hypertext markup language (HTML) page, a Common Gateway Interface (CGI) program, and a Java applet stored on a web server. The web server sends the HTML page when it receives a hypertext transfer protocol (HTTP) request from the user's web browser. This page is quite simple, and its main job is to download the Java applet (bytecode) to the user's machine. The user's Java-enabled browser interprets the bytecode. The applet begins by importing a number of standard Java classes widely available in standard Java environments, such as browsers and developer kits like Microsoft's Visual J++. It also imports the graphics classes developed by AEDC. The user will then see a user-friendly interactive screen, make selections, and click on the "Plot" button. This triggers the applet to open a socket to start a Common Gateway Interface (CGI) program on the web server, which reads data from an ADS file and writes the data to the socket. The plotting applet receives the information and plots the graph within the user's browser display window.

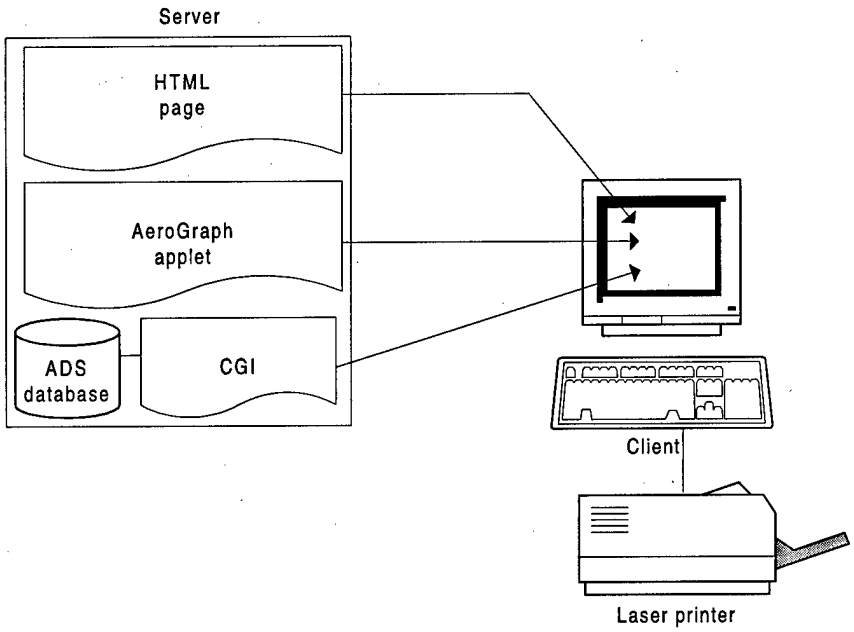

Figure 1. AeroGraph framework.

MODULE 1 - HTML PAGE

The HTML page specifies the name of the class file to be downloaded, the size of the window, the user name, the server name, and the marker file to be used. Currently, this must be set up by AEDC personnel for security reasons.

```
<HTML>
<HEAD>
<TITLE>Plotting ADS data</TITLE>
</HEAD>

<BODY>
<CENTER>

<applet code=Aerograph.class width=650 height=450>

<param name=USERNAME value="pemberton-dl">
<param name=SERVERNAME value="cyclone">
<param name=MARKER value="marker.txt">

</applet>

</CENTER>
</BODY> </HTML>
```

The graphical browser makes it easy to display Java applets using HTML.[5] Users can connect nearly any type of computer to the Internet, and if that computer supports the HTTP, they can program it to send nearly any type of data.

MODULE 2 - CGI PROGRAM

The CGI program is currently written in the C programming language and resides on the web server computer. The Java applet opens a socket to the server's HTTP daemon. The HTTP daemon on the server launches the CGI program and feeds it the selections made by the user from the interactive applet. Next, the CGI program reads the data from an ADS file structure, performs searches for the requested data, and sends the data back to the applet via the socket. Multiple ranges and parameters of data can be read. The CGI program can be easily modified to retrieve data from other file structures without affecting the results of the plotting applet.

MODULE 3 - JAVA APPLET

The Java applet[6] retrieves the data from the socket and plots it. It has the following capabilities:

A star-shaped input panel (Figure 2) allows easy modification of the number of plots.

"Left" decreases the number of plots horizontally by one.
"Right" increases the number of plots horizontally by one.
"Down" decreases the number of plots vertically by one.
"Up" increases the number of plots vertically by one.
"Square in the middle" will increase the number of plots to make the same number both vertically and horizontally. When it reaches the maximum of 16, it will revert to 1 plot.

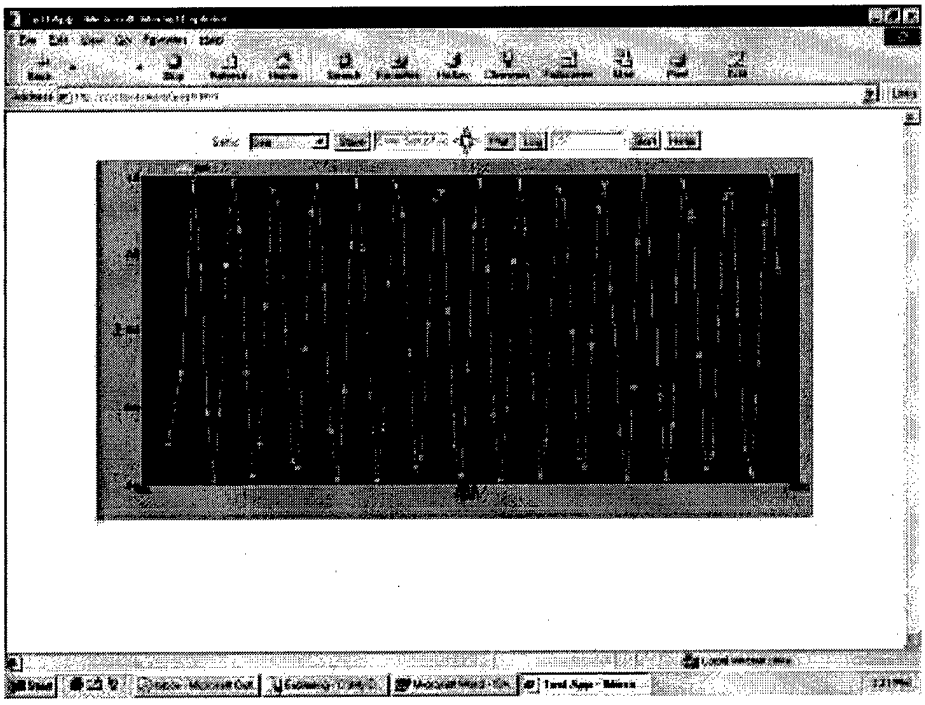

Figure 2. Sample single plot.

Stores plot setups on the server and allows users to select their predefined plot setups.

Allows users to view a run log of their ADS data file.

Allows the following interactive capabilities (Fig. 3):

Enter run numbers to be plotted
Parameter selection
Manual scales
Automatic scales select on/off
Markers on curves select on/off
Gridlines select on/off
Zooming capability-drag mouse across the area of the plot to be zoomed
Redrawing of plot with default limits
Toggle pop-up window that displays the mouse position in user coordinates
Show coordinates of the data point closest to the cursor

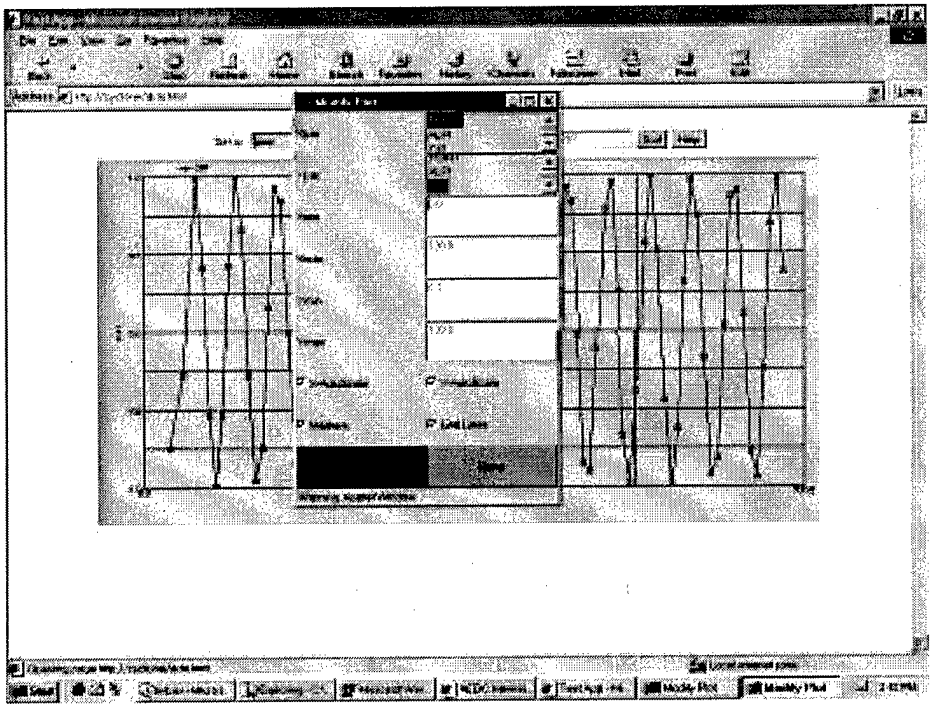

Figure 3. Sample Interactive menu.

Provides a Help page.

Provides tabular data display (Fig. 4):

Selection of five sorting parameters with min and max inputs.
Selection of parameters to be printed.
The resulting display can be copied and pasted from the browser to any Microsoft Office program.

RUN	POINT	ALPHA	MACH
283	1	0.0	0.8
283	2	0.0	0.8
283	3	0.0	0.8
283	4	0.0	0.8
284	1	2.0	0.8
284	2	2.0	0.8
284	3	2.0	0.8
284	4	2.0	0.8
285	1	4.0	0.8
285	2	4.0	0.8
285	3	4.0	0.8
285	4	4.0	0.8

Figure 4. Sample Tabular Display.

Figures 2, 5, and 6 are AeroGraph-generated example plots.

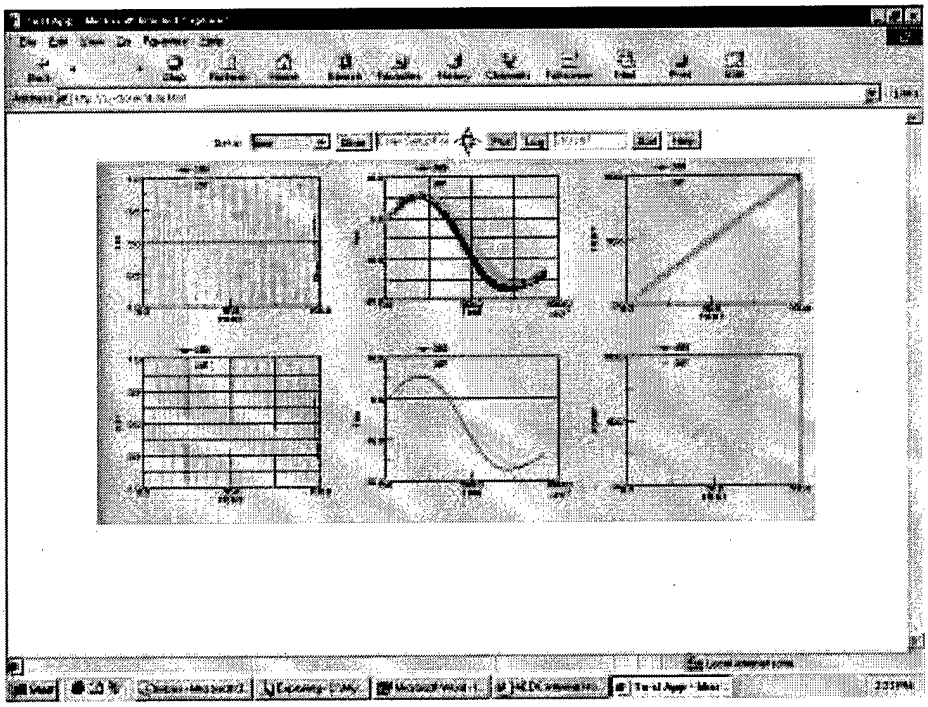

Figure 5. Sample multiple plot capability.

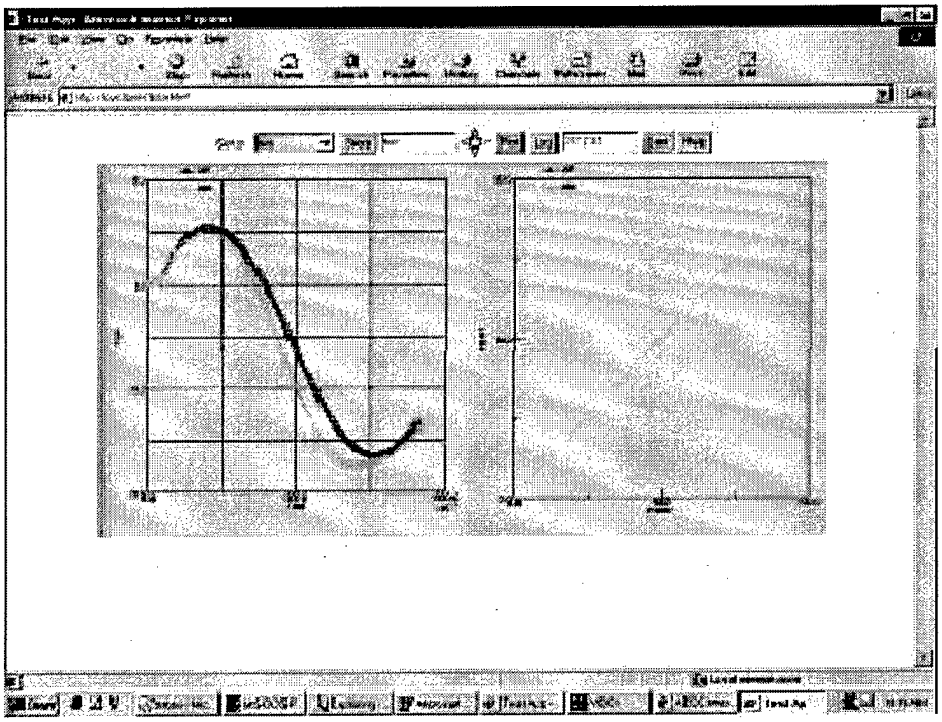

Figure 6. Sample Multiple Plots.

DATABASE

AeroGraph currently reads an ADS database that contains all reduced testing parameters acquired during the test. Several data points are stored with a number indicating the run configuration.[7] As the data are stored, a run log is created that correlates the data with the test configuration.

Example RunLog:

RunLog
283
284
285
287
288

Searching for data that meet certain criteria in multiple ADS files may be performed. Figure 7 is an example Graphical User Interface displayed in AeroGraph for searching/sorting. Parameter ALPI and C44 would be displayed for data with TIME values between 0.0 and 1.0 for the run range 280-290.

INTRANET

The AeroGraph system provides local access to the AEDC wind tunnel facilities through a dedicated, site-wide fiber-optic Intranet. No connections to the WWW Internet are currently permitted. The use of

these isolated networks and subnets provides a level of security. The security level of the data depicts which network is used.

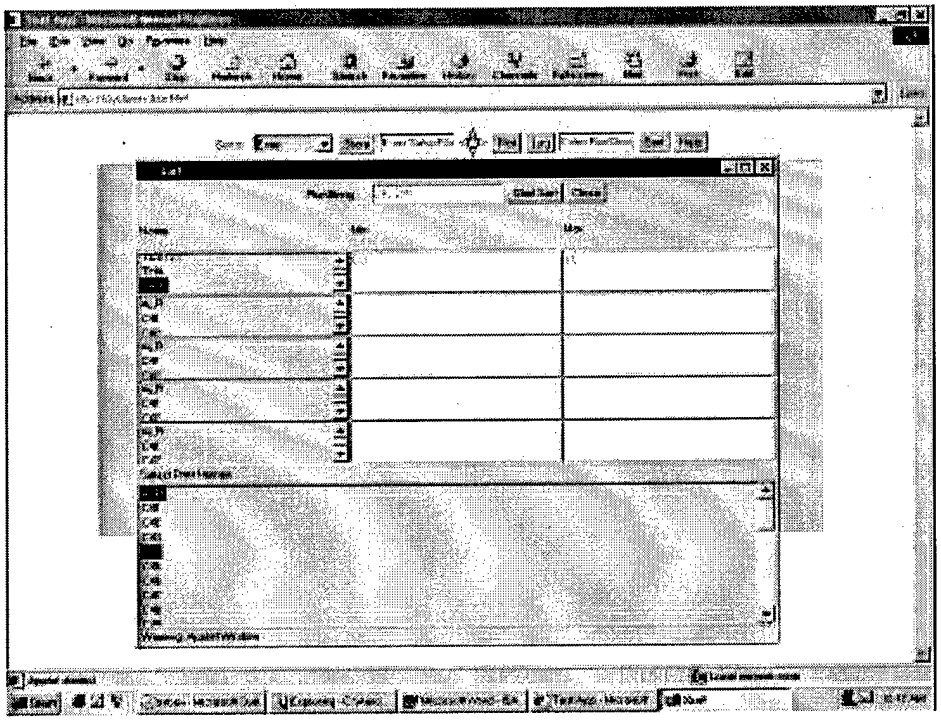

Figure 7. Searching/sorting GUI.

INTERNET

AEDC has several private Internet connections in order to provide remote access to data.

Unclassified:

Defense Research and Engineering Network (DREN)
Non-classified Internet Protocol Router Network (NIPRNET) - Government Network
AERONET - NASA Network

Classified:

Secret Internet Protocol Router Network (SIPRNET)

AeroGraph will execute over any network. The security of the data and the customer requirements determine the type of Internet connection and the data encryption mechanism to be used.

BENEFITS

AeroGraph will provide the following benefits to AEDC.

1. Faster access to near real-time reduced data
2. Fewer engineers required at facility

3. Opportunity to make test critical decisions in near real-time from customer site
4. Remote access to data
5. No plotting package required on the user's computer
6. Nothing new to buy
7. Reduce development cycle time

FUTURE EFFORTS

Future plans for AeroGraph are to incorporate other database structures. AeroGraph has already been modified to read Dynamic Data for the PWT facility. An Oracle database file and powerful meta-data search engines are other possible enhancements. Continuous plotting of data and additional plotting tools have been requested.

SUMMARY

A common goal shared by most of the customers testing at AEDC is to minimize product development cycle time and cost. In order to minimize the cycle time, the customer needs remote access to reduced data during the test for validation and analysis. The availability of the data is of great importance in preventing errors and uncovering problems. The AeroGraph system concept provides the aerospace customer the capability to analyze data during a test to make critical decisions. This allows for immediate data validation, reduction of time required in the tunnel, and reduction of the number of engineers and researchers required on-site. Thus, the ultimate goal of reducing system development cycle time and cost can be realized.

NOMENCLATURE

AEDC	Arnold Engineering Development Center
PWT	Propulsion Wind Tunnel Facility
ETF	Engine Test Facility
VKF	Von Karman Test Facility
ADS	Analysis and Display System (PWT analysis package)
TIGER	Test Interface Graphical Evaluation Resource (ETF analysis package)
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
CGI	Common Gateway Interface

WWW World Wide Web

DREN Defense Research and Engineering Network

NIPRNET Non-classified Internet Protocol Router Network

NASA Numerical Aerodynamics Simulator Facility

AERONET NASA Aerospace Network

SIPRNET Secret Internet Protocol Router Network

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